RAMSSES - Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships

Final Public Conference

17 Nov 2021

Nantes, France

New partnerships and value chains enabling lightweight composite components for ships

WP10 Birgitha Nyström (Podcomp)
WP13 Arthur-Hans Thellmann (Meyer Werft)
WP14 Vito Radolovic (FLOW Ship Design)
WP15 Kristjan Tabri (MEC/Baltic Workboats)

Aim

Overall goal:

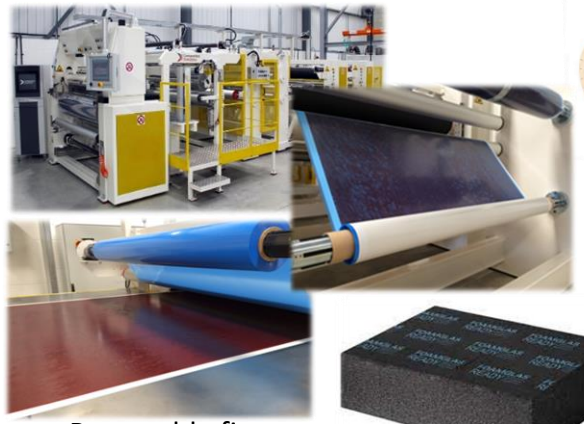
- *Light weighting of ships using innovative materials*

Specific goal for composite solution:

- *Develop an integrated fire, thermal, acoustic AND lightweight composite panel system with competitive price for marine applications, matching requirements from shipyards*

Concept and value chain development

Material concepts development



Renewable fire resistant resin/glass fibre prepreg

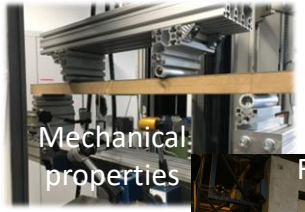
Renewable Balsa core

Incombustible silicate core

Non-combustible, acoustic insulating glass foam core

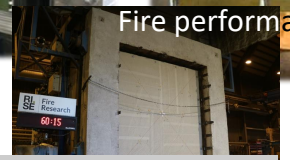
Process development & sample preparation and performance testing

Test samples



Mechanical properties

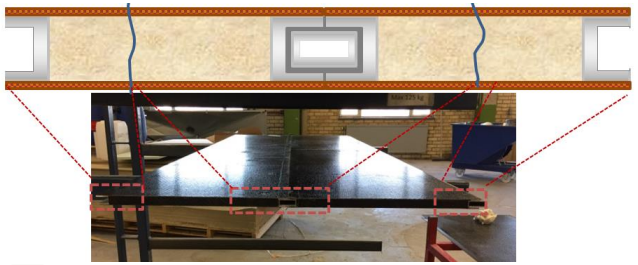
Acoustics



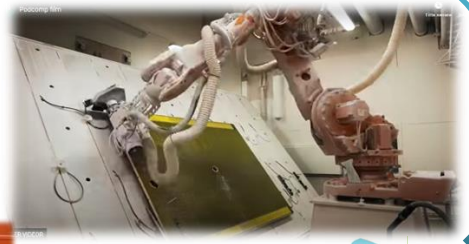
Fire performance

Class A-60 Bulkhead

Product and mounting development

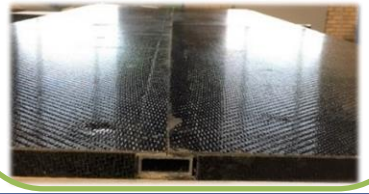


Future: Semi automated process for thermal, acoustic AND lightweight composite panel system at a competitive price



Meyer Werft

Wall panels

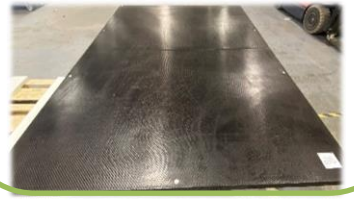


FLOW Ship Design

Car deck panel

Baltic workboats

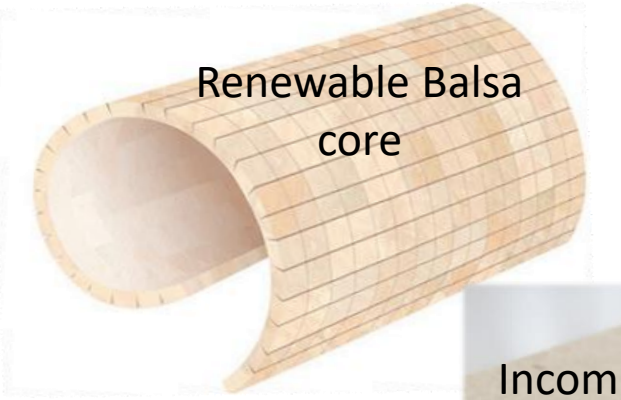
Sun roof panel

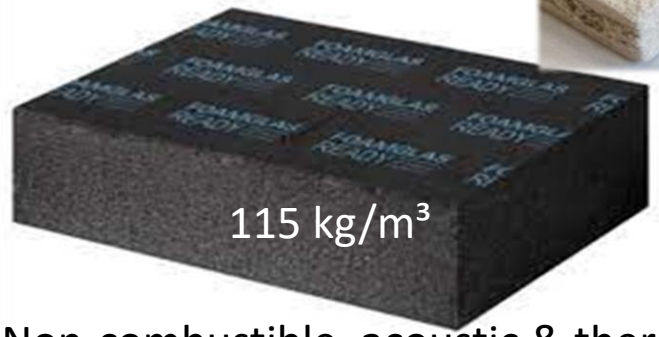


Concept and value chain development

Material concepts development

Renewable fire resistant PFA-resin/glass fibre prepreg

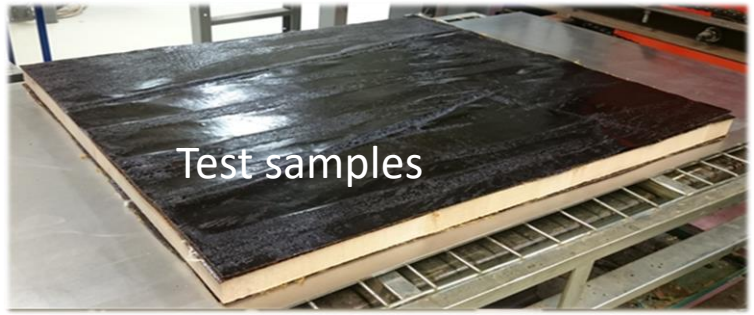


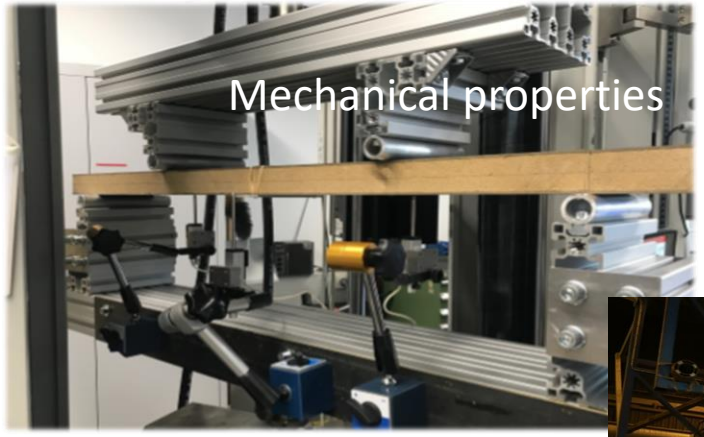


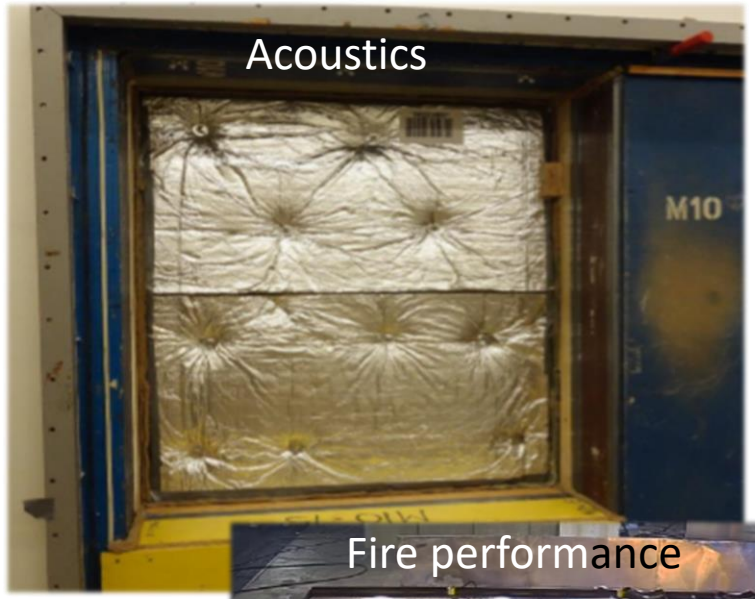
Non-combustible, acoustic & thermally insulating FoamGlass core

Concept and value chain development

Process development & sample preparation and performance testing





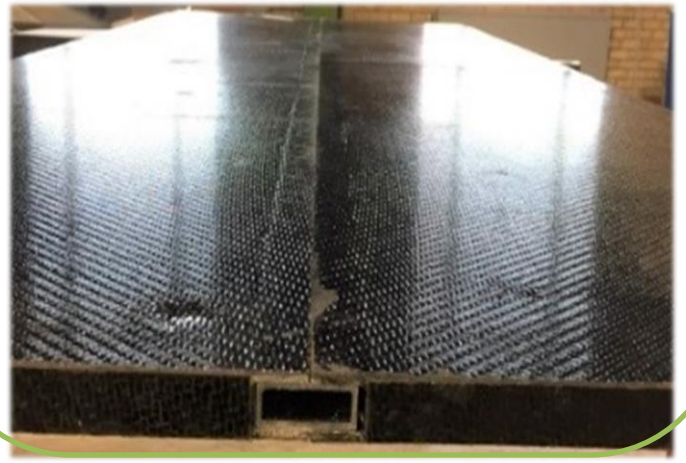


Class A-60 Bulkhead

Concept and value chain development

Meyer Werft

Wall panels

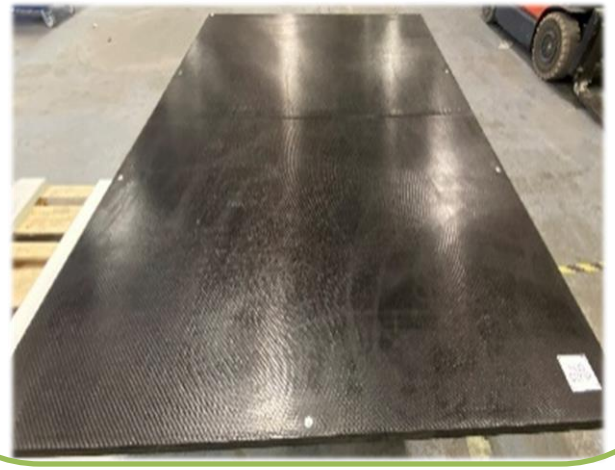


FLOW Ship Design

Car deck panel

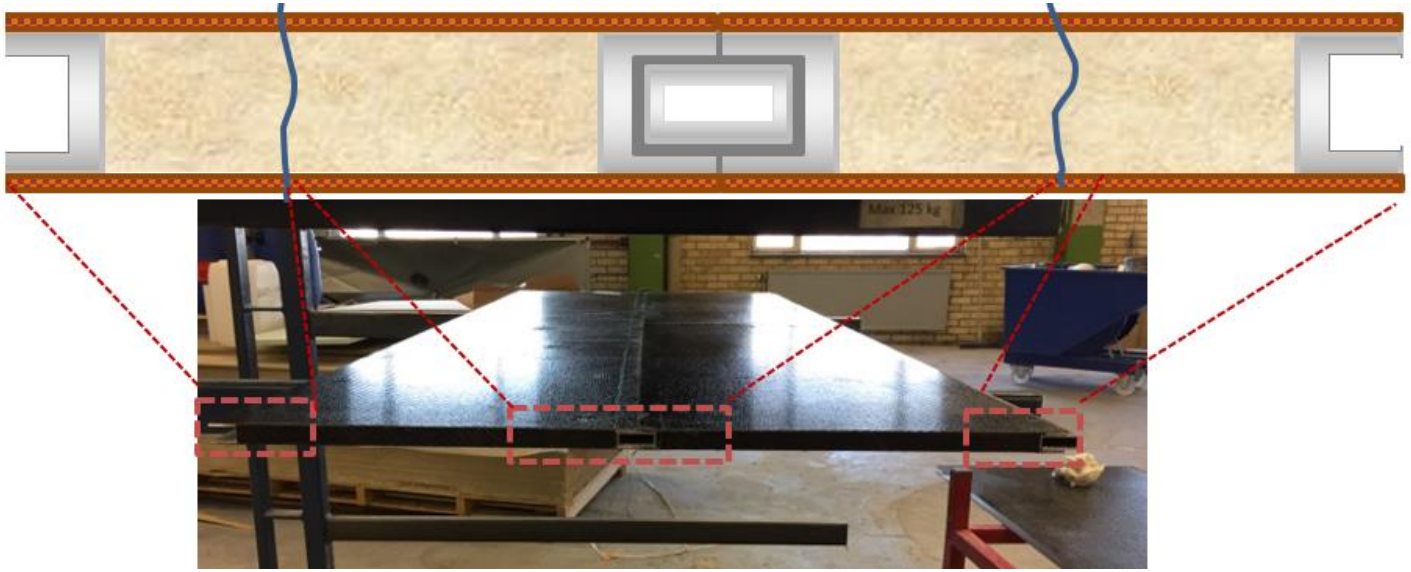
Baltic workboats

Sun roof panel



Concept and value chain development

Production and mounting development

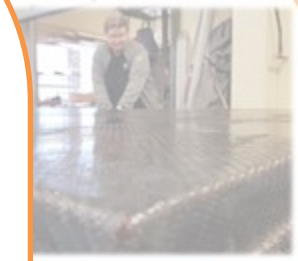


Material

Renewable fire resistant resin/glas fibre prepreg

Future: Semi a process for t acoustic AND li composite panel competitive

development



workboats

oof panel

Concept and value chain development

Future: Semi automated process for thermal, acoustic AND lightweight composite panel system at a competitive price

Meyer Werft Democase – Objectives & Challenges

WP13: Integration of system for internal walls and superstructure of cruise ships into shipyard processes

Objectives:

- Develop highly efficient shipyard process for adaptation, assembly and outfitting of a modular system
- Performing numerical and analytical analysis to pass the requirement on the heat insulation, eigenfrequency, deformation, maximum width and weight of the composites wall panels
- Development of a design catalogue for quick assembly and joining technology between steel and composite component for series production
- Assessment of the influence on the production process

➢ **Introduction of FRP into the yard production process for usage in cruise ships**

Mayor Challenges:

- SOLAS compliant material specification – especially IMO FTP Code fire testing
- Design of a robust composite panel that is compatible with standard shipbuilding processes and tolerances

Benefit:

- Less fuel/energy consumption
- Less emissions
- Less draught
- Better stability
- More passengers/payload
- Heavier attractions on upper decks
- Reduction of maintenance costs
- Improvements of the design possibilities (complexity)
- Functional integration
- Possibilities to react late in the production process

➢ **Lightweight design – a design philosophy with increased performance per definition**

Meyer Werft Democase – Specifications, Conditions & Requirements

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E

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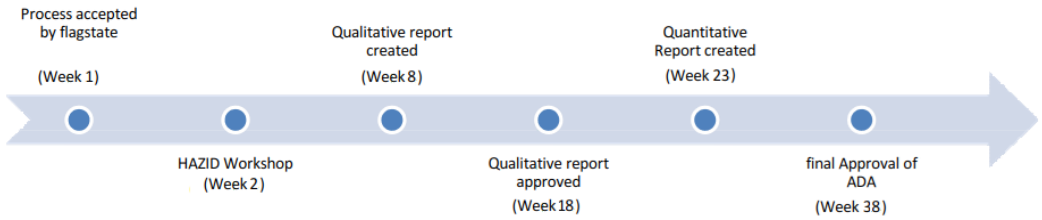
MSC.1/Circ.1574
9 June 2017

INTERIM GUIDELINES FOR USE OF FIBRE REINFORCED PLASTIC (FRP) ELEMENTS WITHIN SHIP STRUCTURES: FIRE SAFETY ISSUES

FRP Interim Guidelines were approved by MSC 98 in summer 2017

- consistent approach is taken with regard to standards of fire safety of ships
- the level of fire safety afforded by the provisions of SOLAS chapter II-2 is maintained
- Guidelines on alternative design and arrangements for fire safety



Technical properties & Requirements:

- 38 Requirements were identified, categorized with examples
  - technical requirements
    - Accelerations / vibration / loadings specification
    - Fire behavior: 2010 FTP Code Part 2, 5, 10, 11
    - Temperature, Humidity, UV, salt water resistant
    - Heat/Sound/ insulation
  - Connections
    - Various types, all with fire safety properties
  - Surface
    - Paintable in white
  - Handling & Processing
    - Outside storage and forklift transportation
  - Refurbishment & Flexibility
    - no "hot work" disconnectability
    - Penetrations/modifications on board
  - Well being
    - Free of smell

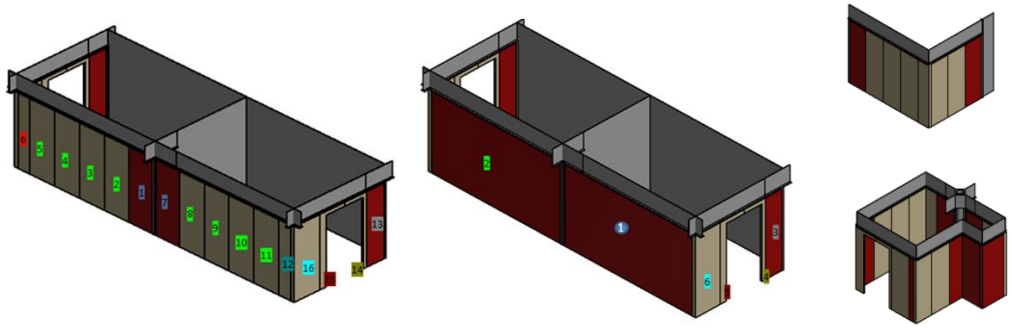
Meyer Werft Democase – Design Concept

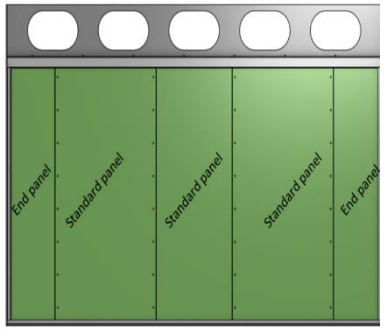
Objectives:

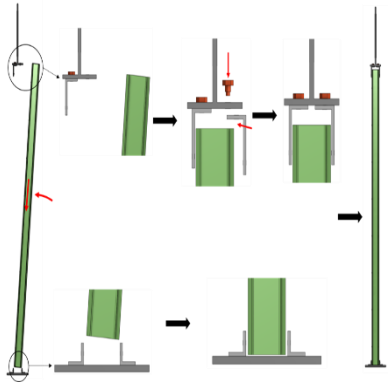
- Modular concept to be able to exchange >80% of these walls in a serial production with high potential of standardization
- Standardized & easily to be mounted on-board of the vessel even at a very late stage of production

Design option 1
Assembly in block Hall

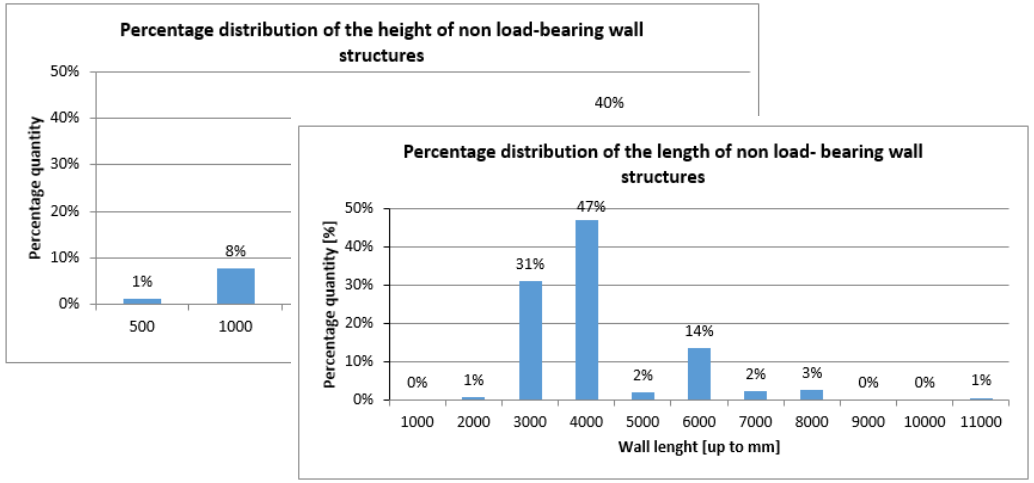
Design option 2
Assembly in drydock

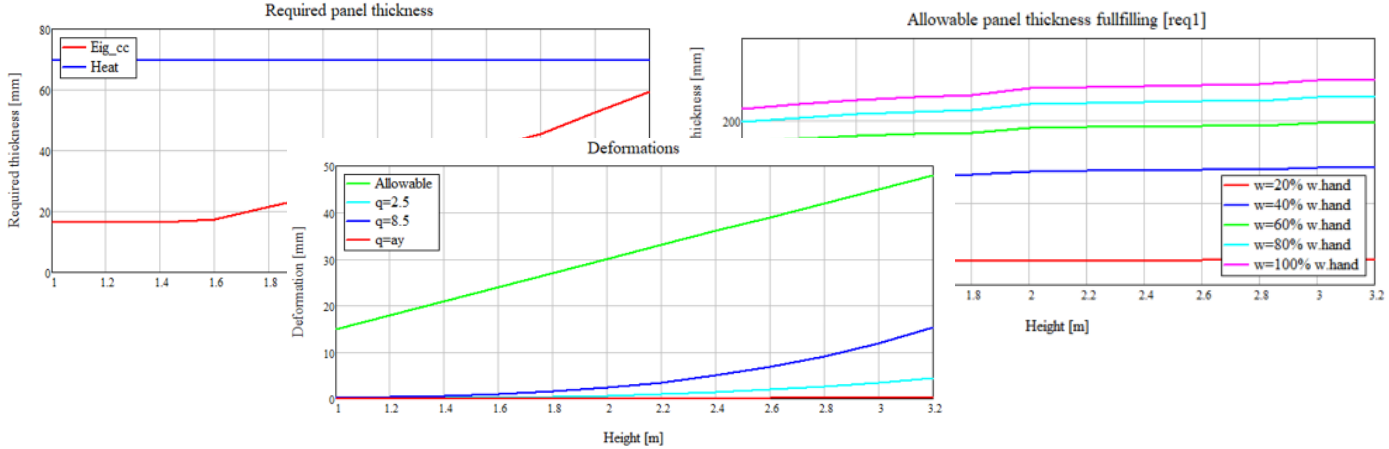






- Research performed to analyze the distribution of height and length of all walls onboard and the dimensions of the panels to fulfill the requirements with respect to material properties





Meyer Werft Democase – Testing

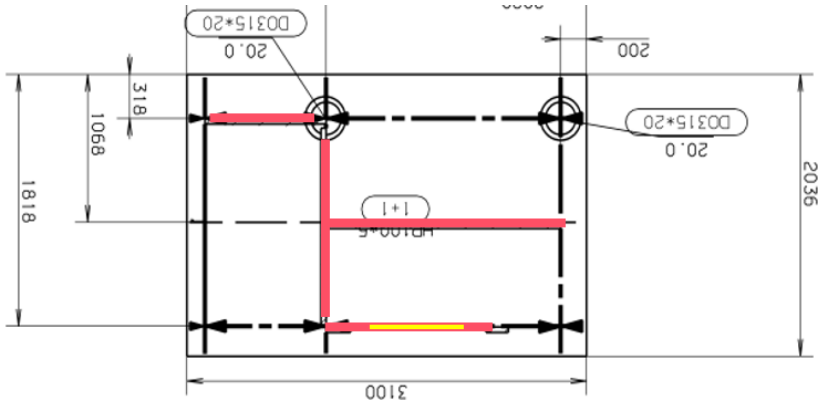
Objectives: Approval for installation on board a SOLAS vessel

- **Mechanical testing (IFAM):**
  - 80 tests are planned – 370 performed
  - Density, Reinforcement content & Glass transition temperature
  - Tensile, Compression, ILSS & Shear
- **Fire testing (RISE):**
  - 13 small-scale tests and 2 full-scale tests planned
  - 82 small-scale tests and 4 full-scale tests performed
  - ISO 5660-1, cone calorimeter, screening for FRM-test
  - Part 2, smoke and toxicity
  - Part 5, spread of flame
  - Part 10, FRM-test
    - 2 tests performed – EP failed at 16:35 / PFA at 12:25
  - Part 11, FRD-test
- **N&V testing (RISE):**
  - 2 tests planned - 4 panels tested, ranging from 31 to 33 dB

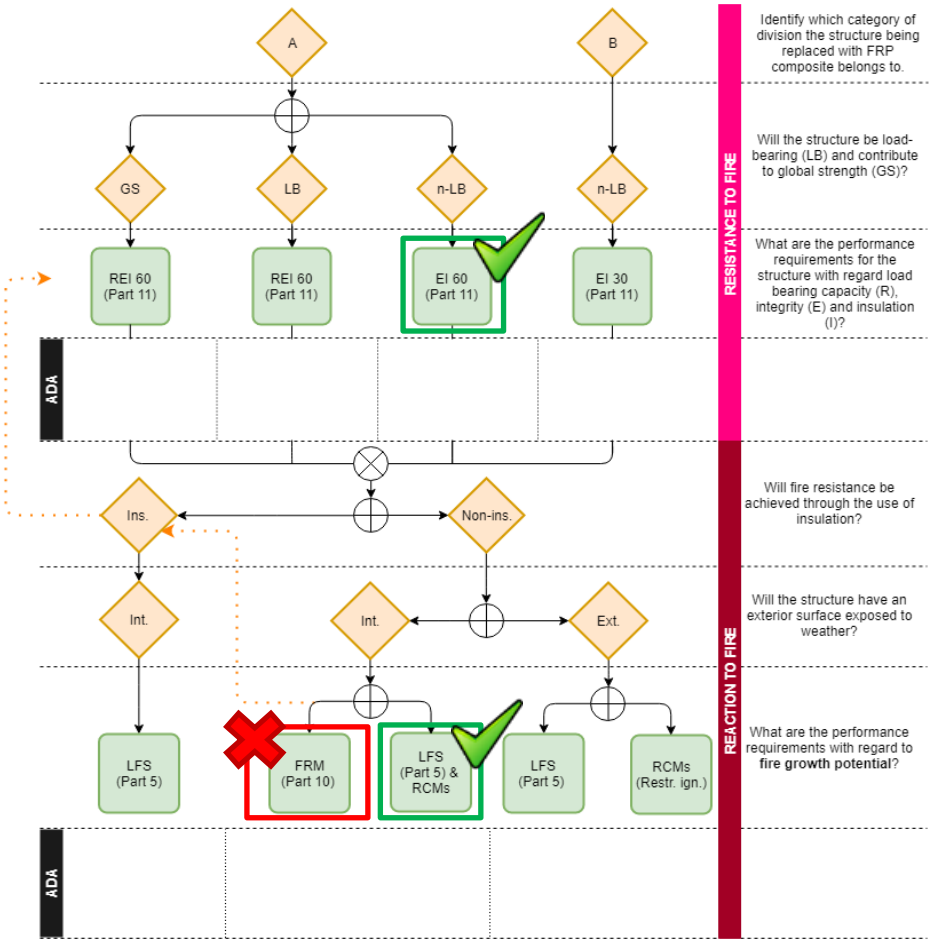
Class FRD-60 Bulkhead

Meyer Werft Democase – Demonstrators

On-Shore Demonstrator:
WP13 – mechanical High-Performance Material

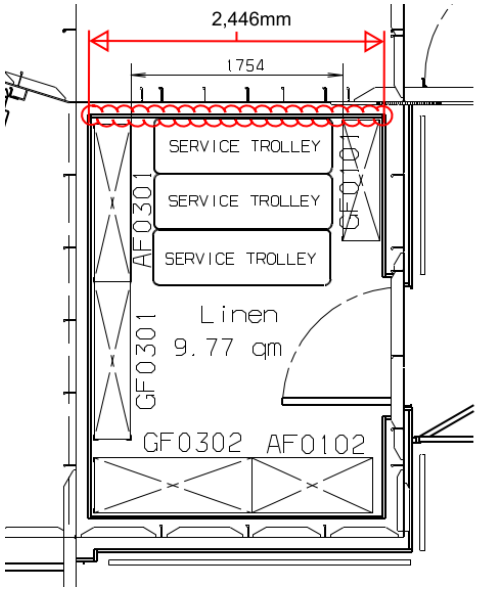


On-Board Demonstrator:
WP10 – challenging the fire safety requirements



anorganic core + gfrp laminate

- ✓Part1 passed – core material
- ✓Part 2 & 5 passed
- ✓Part11 passed (A60)
- ✓FLC: calorific value < 45MJ/m²



Meyer Werft Democase – Results

- Excessive fire testing lead to a huge progress in the understanding of the fire performance and the contribution of each substituent to the overall performance
- Weight reduction of up to 35% could be reached by the installation of FRP-panels
- LCPA analysis shows that the application of composite panels will bring economical and ecological benefit for shipyard and the ship owner by to reducing the emission level during production and operation and increases the NPV
- The assembly procedure of the onshore demonstrator was performed successfully
- Beneficial properties of the design and process concept could be shown but also ones which needs to be optimized for a successful installation onboard

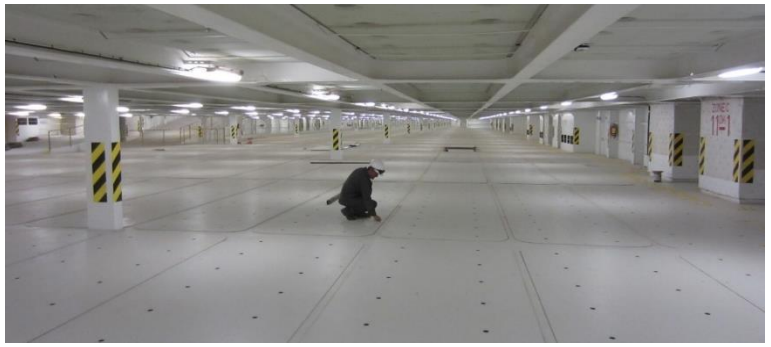
FLOW car deck - Background

DELIGHT TRANSPORT
(FP6-031483, 2006-2010)

- Cargo deck of composite materials for RO-RO vessels developed and tested at full scale
- Approval in principle

m/v SIEM CICERO

- 7000 CEU vehicle carrier
- Delivered at Uljanik shipyard 2017.
- 12600 m2 modular composite deck structure
- SOLAS compliant



RAMSSES
(2017-2021)

- Design and development by application of new composite technologies

FLOW car deck – Objectives&Challanges

Objectives

- Investment cost and production lead time reduction
- weight reduction→ Fuel oil consumption and CO2 emission reduction
- joint development

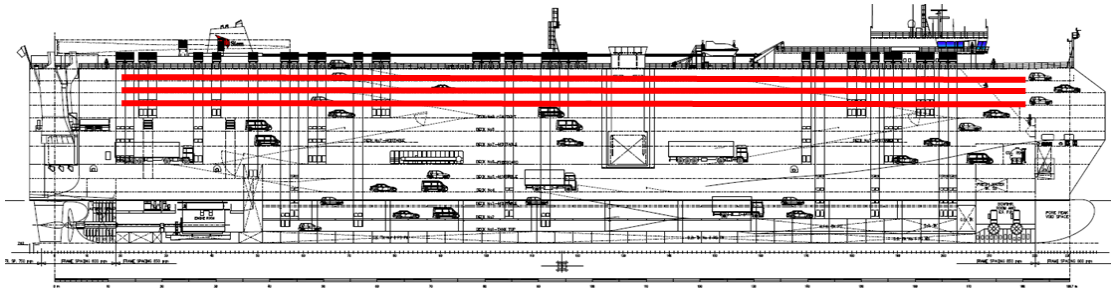
Challenges

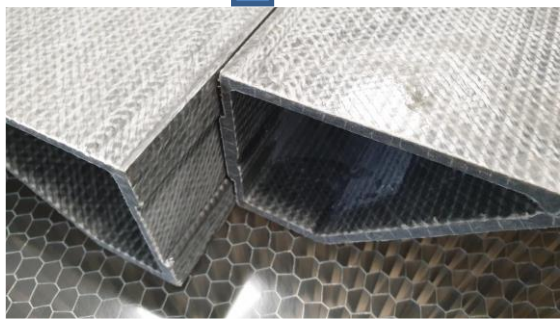
- design of a robust composite module that will allow standard shipbuilding tolerances
- improved composite/steel arrangement with respect to production, assembly, cargo operation (flush deck, lashing), reduced cost

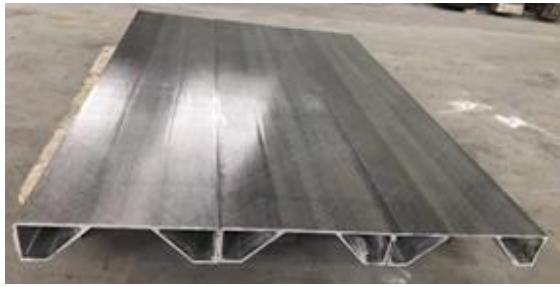
Technology

- Pultrusion technology (WP14):
  - Pultruded FRP profiles considered as main solution
- Sandwich technology (WP10):
  -Podcomp's balsa PFA sandwich developed and produced, using same geometry as modules on the base design, for full scale fire tests

m/v SIEM Cicero used as base design







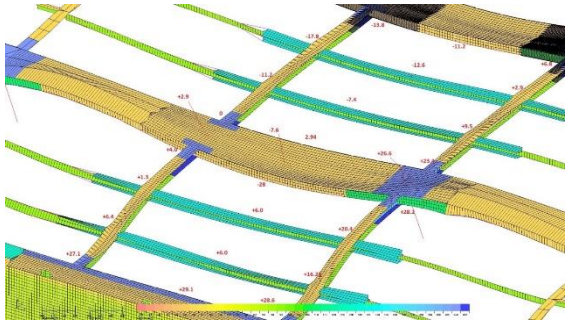
FLOW car deck-Work implemented

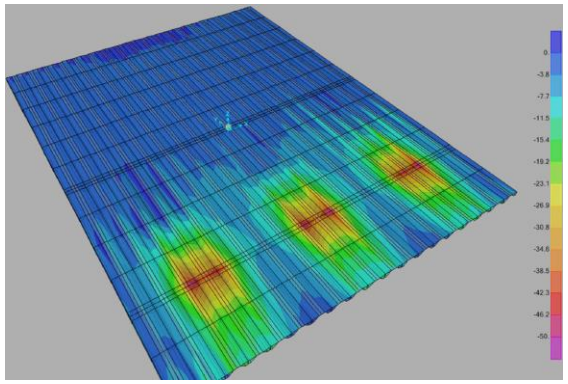
Component design and optimization

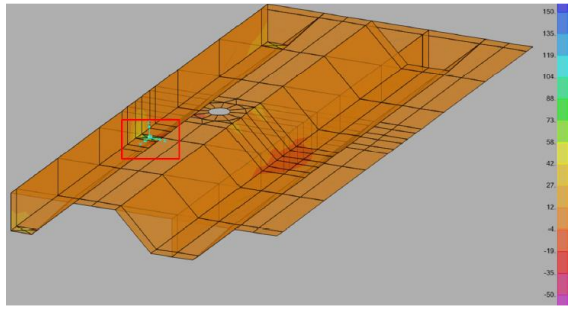
- Deck structure arrangement
- Composite module optimization
- Steel supporting structure optimization
- Connection details
- Composite module equipment (cargo lashing)

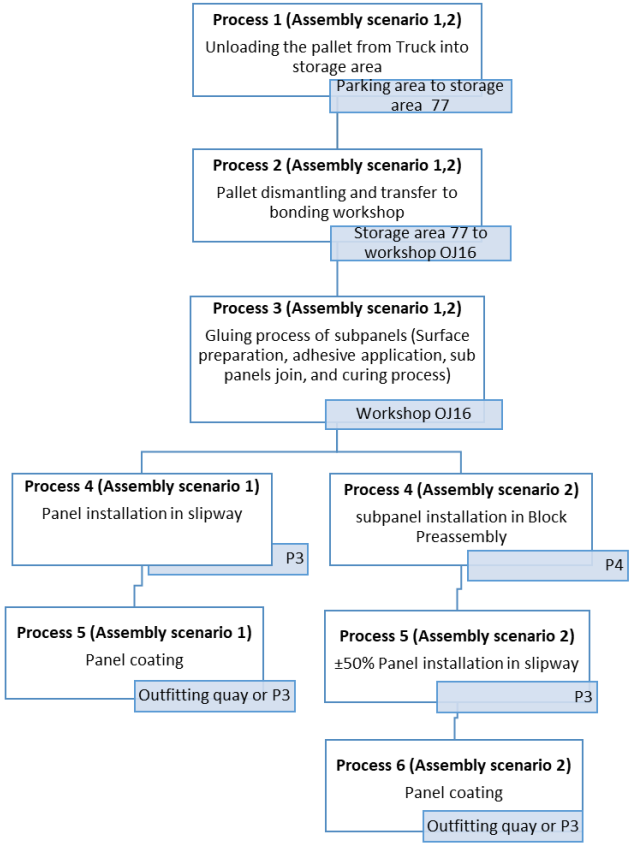
Production process engineering and LCC

- 2 business models, several production scenarios assessed
- scenarios simulated to support the analysis on the lead time, resources, and production cost
- real production times incorporated after the production of the demonstrator





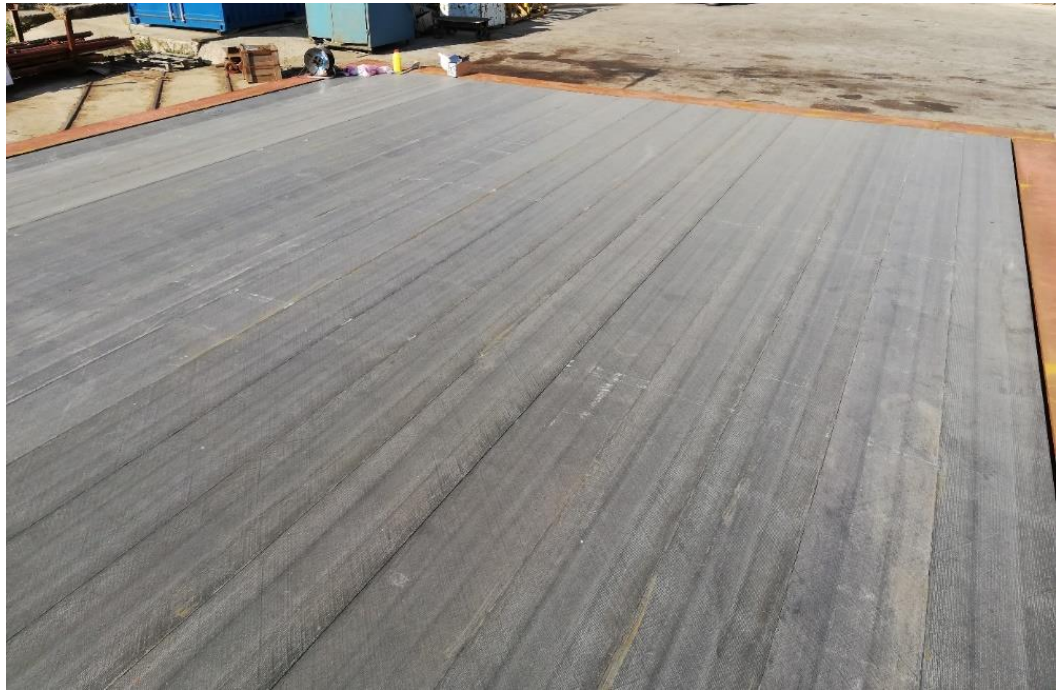




FLOW car deck-Work implemented

Demonstrator production

- Shipyard environment
- Composite profiles produced at OCS facilities
- Production process data assessed

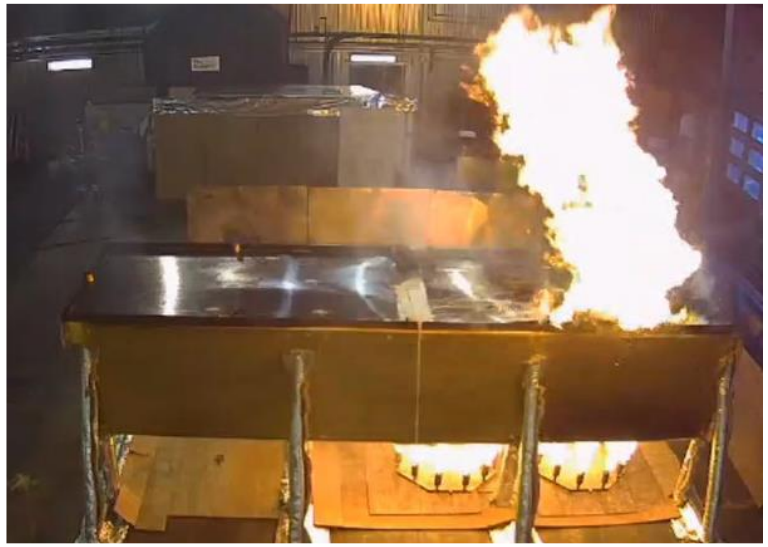


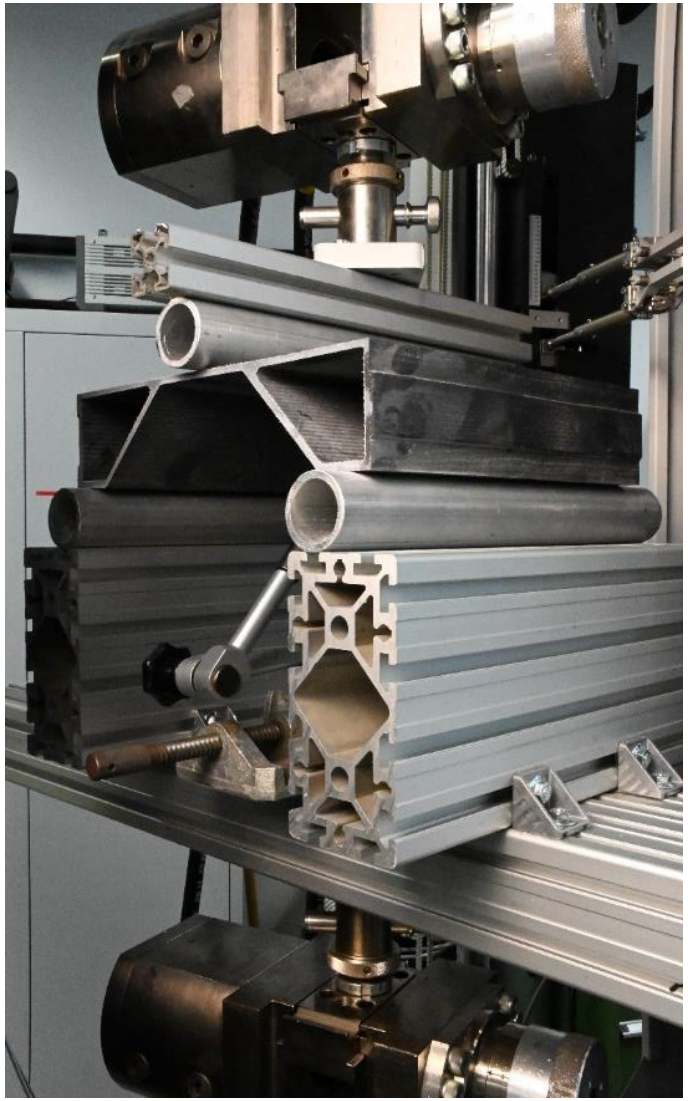
FLOW car deck-Work implemented

Testing

- Full and small scale fire tests (RISE)
  - Pultruded profiles module
  - Balsa PFA sandwich
- Mechanical tests (IFAM)
- Site demonstrator testing (FLOW, OCS)

→ **Design parameters confirmed**





FLOW car deck-Results

- weight reduction of 14 % compared to conventional steel decks, but a weight increase of 13% compared to the base design with composite sandwich panel system

- Reduced fuel consumption up to 2 % (1 t/day) or increased payload for 400 t compared to design with conventional steel decks

- Comparing the results with conventional steel production of the decks, the RAMSSES panel production reduces the lead time more than 10 % and the production costs by almost 20 %

- From the LCPA study perspective, the application of modular decks made of pultruded GFRP profiles can bring benefits to the future cash flow and environmental aspects:
  - reduce the emission level during production and operation up to 0,9% and
  - the future cash flow NPV value can be up to 0,71% compared to the application of steel decks.

- **The production and assembly procedure was performed successfully, within required tolerances and demonstrated to be successful for application at steel shipyard conditions.**

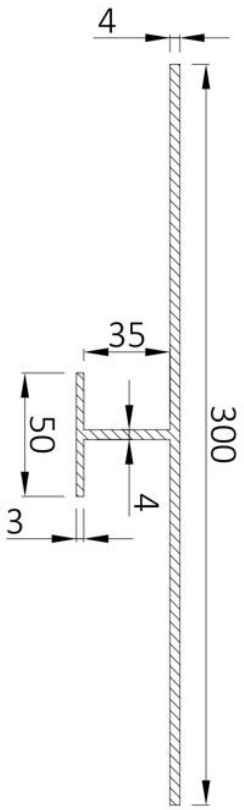
Baltic Workboats: composite deckhouses

- Focus on composite deckhouses for workboats
- **OBJECTIVE: Reduction of the weight and assembly time** for panels for the superstructure and deckhouses of aluminium crafts by implementing light weight structures

PANEL SOLUTIONS STUDIED

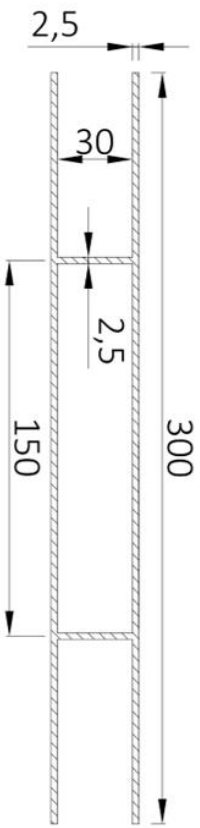
CURRENT SOLUTION

SINGLE SKIN AL PANEL

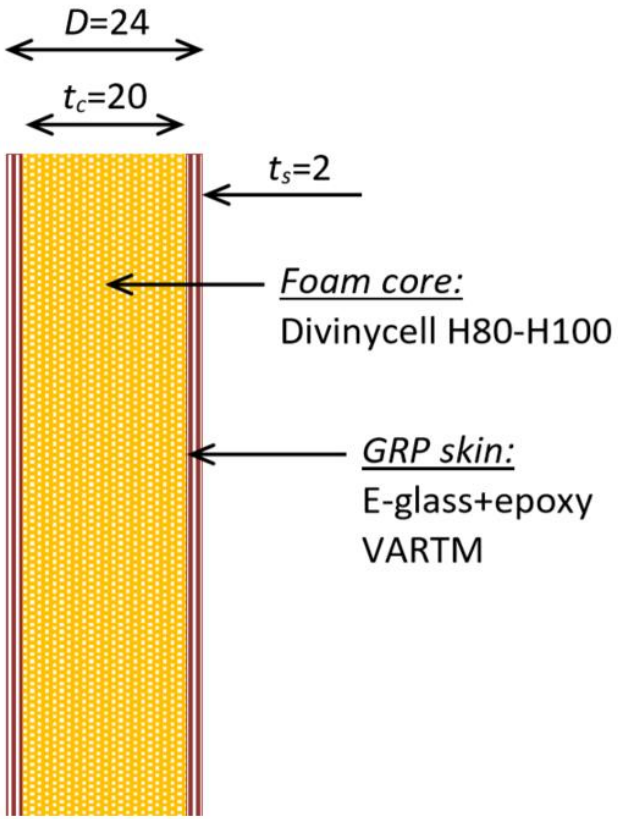


NEW SOLUTIONS

AL SANDWICH PANEL

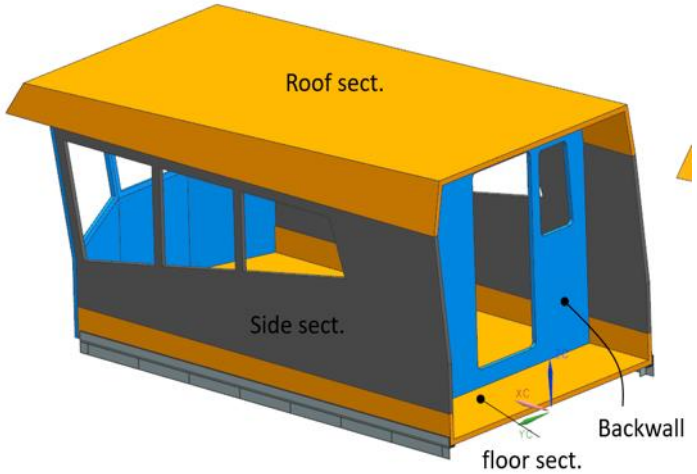


CONV. COMPOSITE PANEL

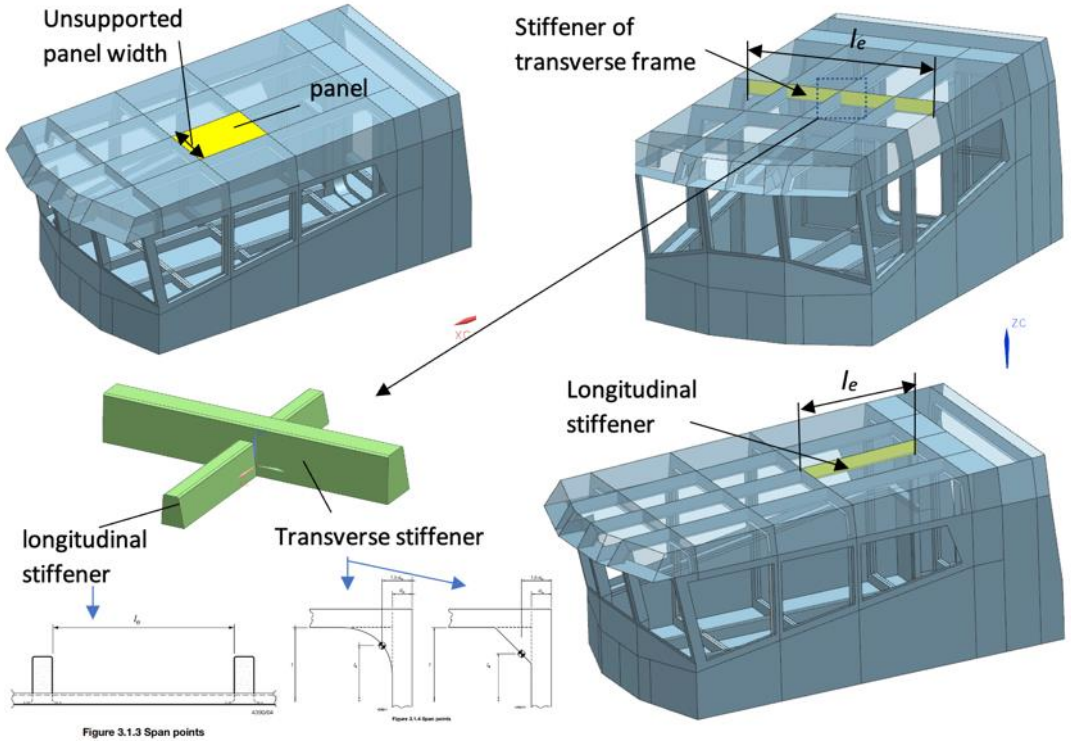


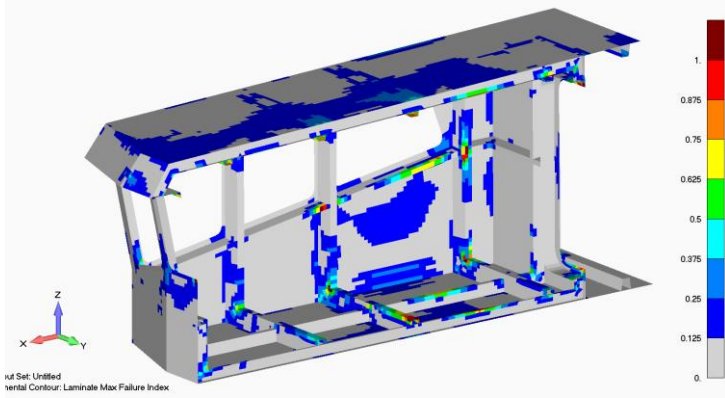
FIRE RESISTANT COMPOSITE PANEL

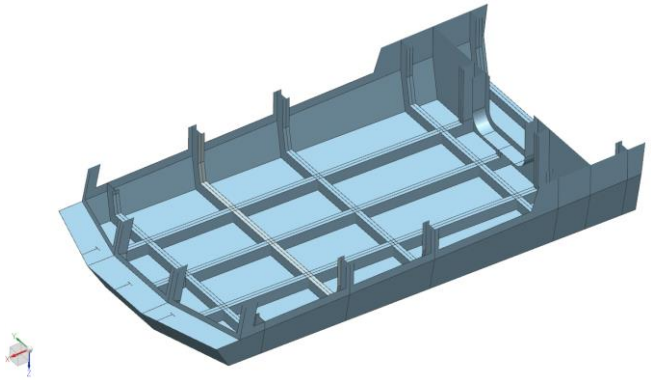
MODULAR DECKHOUSE USING SANDWICH PANELS



Section	Design load, kN/m2	Fire class	Panel thickness, mm	Weight reduction, %
Roof sect.	28	A0	50	25
Side sect.	28	A0	50	20
Front sect.	28	A0	50	20
Backwall sect.	28	A0	50	20
Floor sect.	28	A60	50	20





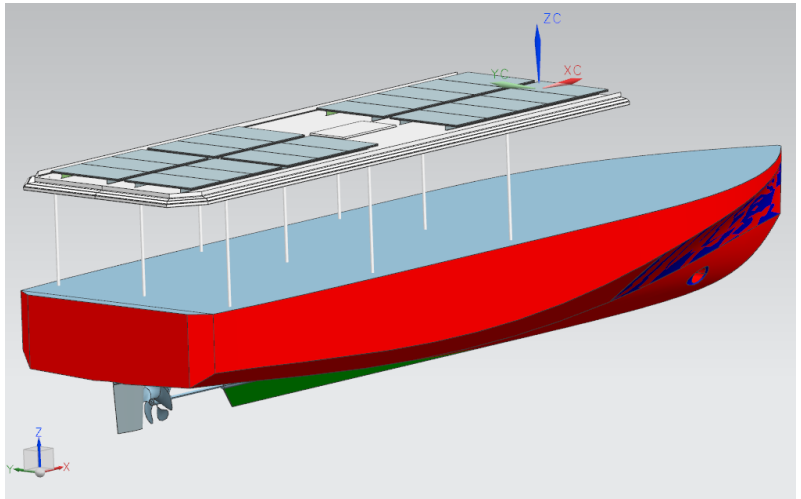


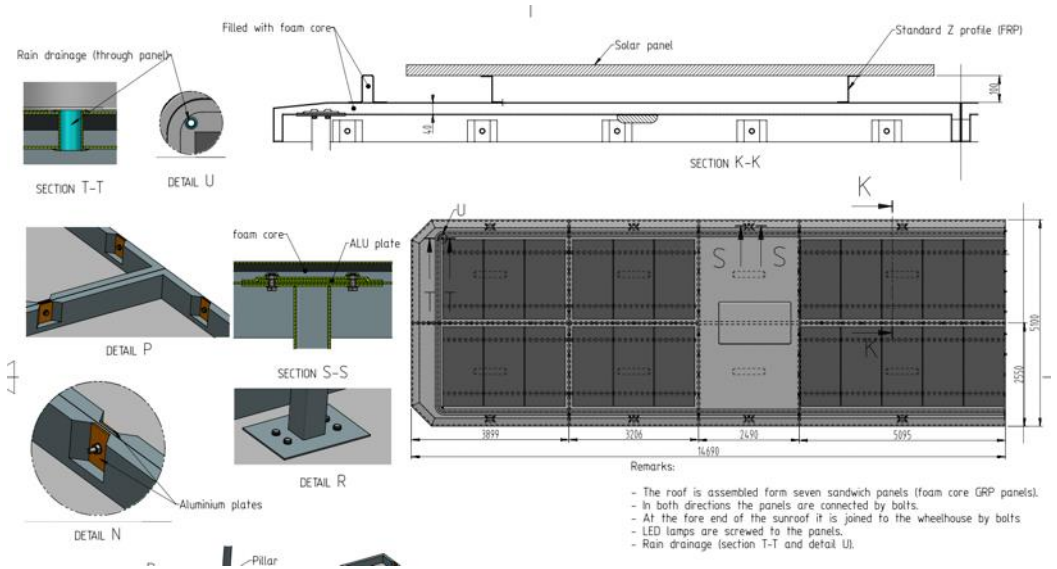
DEMONSTRATOR: A SUN ROOF OF A RIVER BOAT

- To test the concept **of fire-resistant panels**, a sun-roof of a small passenger vessel was considered.
- Initial aim was to produce the whole sun-roof for the actual vessel.

SUN ROOF DESIGN & ASSESSMENT USING FIRE RESISTANT PANELS

DESIGN





STRUCTURAL ASSESSMENT

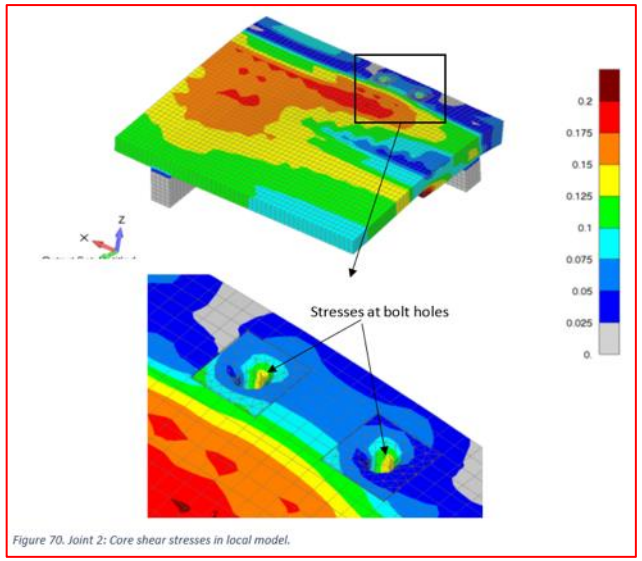


Figure 70. Joint 2: Core shear stresses in local model.

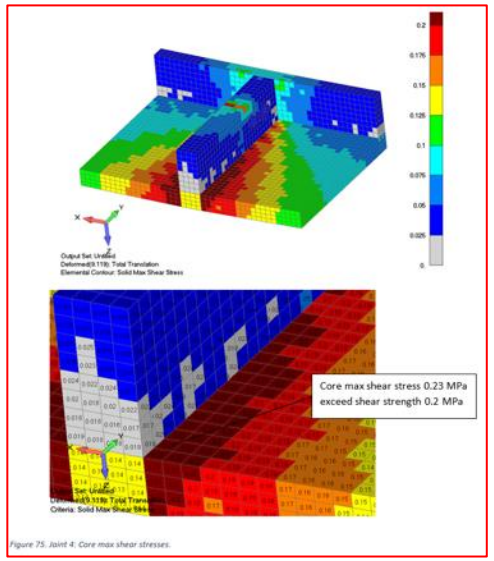
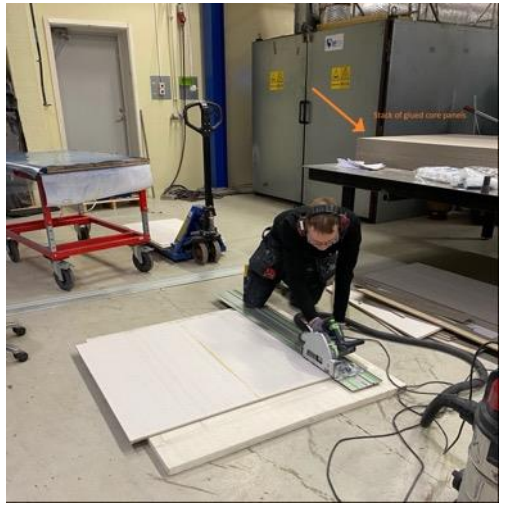


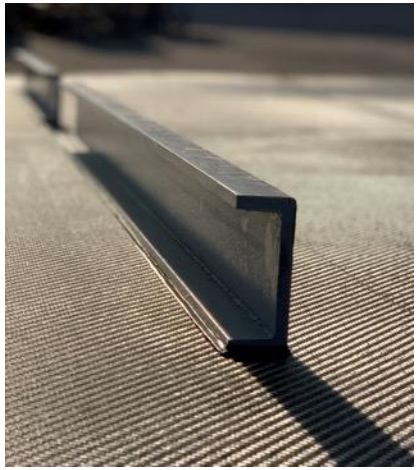
Figure 75. Joint 4: Core max shear stresses.

- Concerns regarding the shear strength at joints
- Onshore demonstrator was built instead on the sun-roof at actual vessel

DEMONSTRATOR: PART OF THE SUN ROOF

DEMONSTRATOR DESIGN AND PRODUCTION





Baltic workboat CONCLUSIONS

- Double skin AL panels are not reasonable for midsize ships where already small thicknesses are used for single skin panels
- Conventional composite sandwich panels offer lighter alternative
- Novel fire-resistant panels should be still developed towards more suitable mechanical properties

VARIABLE	SINGLE SKIN AL PANEL	DOUBLE SKIN AL PANEL	CONV. SANDWICH PANEL	FIRE.RES. SANDWICH PANEL	Unit
Neutral axis, *NA*	0.8	1.75	1.2		cm
Moment of inertia, I_k	24.22	[illegible]	29.78		cm^4
Sectional modulus, Z_{upper}	31.43		24.82		cm^3
Sectional modulus, Z_{lower}	7.06		24.82		cm^3
Bending stiffness, k_{mm}	1,2E+02	[illegible]	115		N/mm
Mass per sqm	**13,4**	**14.9**	**9.6**	**19.4**	**kg/m^2**
Mass per sqm w. fire insulation	**17.0**	**18.5**	**13.4**	**19.4**	**kg/m^2**

REASONABLE AT t >6 mm

Weight ↓ shear strength ↑

*Includes fire resistant insulation.

FINAL CONCLUSIONS

- RAMSSES smart track to approval shows a way how to reach equivalent safety to comply with the SOLAS requirements
- Composite solutions can reach between 25-30 % weight reduction to comparable steel solutions
- The collaboration between RAMSSES partners has enabled development of components to fulfill the requirements and demonstrate final products

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